The
Electrochemical
Society • • •

100th Meeting

DETROIT, MICHIGAN
October 9th - 12th, 1951

LOCAL COMMITTEE

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The Electrochemical Society

One Hundredth Meeting

Tuesday through Friday

October 9, 10, 11, and 12, 1951

CONDENSED TECHNICAL PROGRAM

Batteries

Thursday morning, October 11—9:00 A.M.-12:30 P.M.
Friday morning, October 12—9:00 A.M.-12:30 P.M.
(Ivory Room)

Corrosion (Abstracts 1-23)

Wednesday morning, October 10—9:15 A.M.-12:10 P.M.
Wednesday afternoon, October 10—2:00 P.M.-4:30 P.M.
Thursday morning, October 11—9:00 A.M.-12:30 P.M.
Thursday afternoon, October 11—2:00 P.M.-4:00 P.M.
(Michigan Room)

Electrodeposition (Abstracts 24-38)

Thursday afternoon, October 11—1:50 P.M.-4:00 P.M.
Friday morning, October 12—9:00 A.M.-12:00 M.
Friday afternoon, October 12—2:00 P.M.-5:00 P.M.
(Bagley Room)

Electronics

Wednesday morning, October 10—10:00 A.M.-1:00 P.M.
(Bagley Room)

Wednesday afternoon, October 10—2:00 P.M.-5:00 P.M.
(Ivory Room)

Electro-Organic Chemistry (Abstracts 39-49)

Wednesday morning, October 10—9:30 A.M.-12:00 M.
Wednesday afternoon, October 10—2:00 P.M.-4:30 P.M.
Thursday morning, October 11—9:00 A.M.-12:00 M.
(Parlor F)

Electrothermic-Industrial Electrolytic

Wednesday afternoon, October 10—2:00 P.M.-5:00 P.M.
(Bagley Room)

GENERAL INFORMATION

Convention Headquarters will be at the **Statler Hotel,** Washington Boulevard at Grand Circus Park, Detroit 31, Michigan. The registration desk will be located on the Ballroom Floor.

Rates for rooms will be: single bedroom $5.00 to $11.00; double bedroom with double bed $8.50 to $11.00; twin bedroom $9.50 to $14.00; suites, consisting of a parlor and one bedroom, $16.00 and $24.00 single occupancy, and $18.50 to $28.00 double occupancy.

Requests for room reservations should be made to: Front Office Manager, Statler Hotel, Washington Boulevard at Grand Circus Park, Detroit 31, Michigan. Identity with the Society should be established in order to insure allocation of rooms from the block which has been reserved.

REGISTRATION

The registration desk located in the Ballroom Foyer opens Tuesday, October 9, from 7:30 P.M. to 9:30 P.M.; Wednesday, October 10, 8:30 A.M. to 6:30 P.M.; Thursday, October 11, 8:30 A.M. to 5:00 P.M.; Friday, October 12, 8:30 A.M. to 12:00 M.

The registration fees are:

Members	$7.00	Students	$2.00
Ladies	$3.00	Other Nonmembers	$9.00

If a nonmember fills out an application blank and pays his first year's dues, the difference between the nonmember and the member registration fee will be applied to his dues, if he is elected.

Advance Registration

Due to the necessity of arranging transportation for the plant trips, it is imperative that those members desiring to avail themselves of this opportunity notify the Local Committee prior to the opening of the convention. For this purpose, advance registration cards have already been mailed to you. Be sure to return these cards well ahead of convention dates since the number taking the trips will be limited and the order of selection will be on a first come, first served basis. All advance registrations should be sent to Mr. William P. Innes, 20114 Goulburn, Detroit 5, Michigan.

PALLADIUM MEDAL LECTURE

Dr. Carl Wagner of Massachusetts Institute of Technology will deliver the first Palladium Medal lecture on Thursday, October 11, in the Michigan Room at 4:00 P.M.

LUNCHEONS AND DINNERS

Wednesday Dinner and Entertainment

A cocktail hour, starting at 6:30 P.M., followed by an informal dinner, at 7:30 P.M., will be held in the Ballroom. Entertainment starts at 9:00 P.M., with dancing at 10:00 P.M.

Carl E. Heussner Memorial Luncheon

The Carl E. Heussner Memorial Luncheon, honoring the late Carl E. Heussner will be held at 12:30 P.M., Thursday, October 11. Speaker for this event will be Paul Ackerman, Chief Engineer, Chrysler Corporation.

Palladium Medal Banquet

At 6:30 P.M. Thursday evening a Reception will be held for Dr. Carl Wagner, first Palladium Medalist, to be followed at 7:30 P.M. by the formal Award Dinner. Malcolm Bingay, editorial director of the *Detroit Free Press* will be the dinner speaker. There will be music by a string ensemble during dinner.

Friday Evening

Friday evening has been left open for members visiting Detroit to be free to enjoy a trip about the Motor City to see its most interesting features and also some of the 250th Anniversary celebrations.

LADIES' PROGRAM

Wednesday afternoon—An informal tea from 3:00 to 5:00 P.M.

Thursday morning—An identified audience participation television program. At noon, Thursday, luncheon and cards at the Country Club.

Friday noon—A luncheon, at which it is planned to have Fran Harris, WWJ-TV commentator, and a musical program.

PLANT TRIPS

Three plant tours of special interest to electrochemists are scheduled:

Wednesday afternoon—Chrysler Engineering and Research Laboratories. This trip will leave from the Statler at 1:30 P.M.

Thursday morning—Ford Waste Disposal Plant recently built at Monroe, Michigan. Tour leaves the Statler promptly at 8:30 A.M.

Friday morning—Dow Chemical Company at Midland. This will be an all-day trip; buses leave the Statler promptly at 8:00 A.M. and return at 8:00 P.M.

As space for plant trips is limited, reservations will be made in the order of receipt of returned

reservation cards. Proof of citizenship may be required.

LUNCHEONS AND BUSINESS MEETINGS OF DIVISIONS

Battery Division—Friday, October 12, 12:30 P.M., place to be announced.

Corrosion Division—Wednesday, October 10, 12:30 P.M., place to be announced.

Electrodeposition Division—Friday, October 12, 12:30 P.M., place to be announced.

Electronics Division—Wednesday, October 10, 1:00 P.M., place to be announced.

Electro-Organic Division—Wednesday, October 10, 12:30 P.M., place to be announced.

Electrothermic and Industrial Electrolytic Divisions—joint luncheon, Wednesday, October 10, 12:30 P.M., place to be announced.

BOARD AND COMMITTEE MEETINGS

Tuesday, 10:00 A.M.—Meeting of the Ways and Means Committee in Parlor B.

2:00 P.M.—Meeting of the Board of Directors in the Bagley Room.

Wednesday, 4:30 P.M.—Meeting of the Local Section Advisory Committee in Parlor A.

4:30 P.M.—Meeting of the Membership Committee in Parlor B.

4:30 P.M.—Meeting of the Sustaining Membership Committee in Parlor C.

Meeting of the Editorial Staff. Time and place to be announced.

NOTICE TO SYMPOSIA CHAIRMEN

Mr. Glenn Coley, Chairman of the Educational Committee, requests the presence of each day's symposia chairmen at an informal breakfast meeting, 7:30 A.M. in the Cafe Rouge each morning of the convention.

DISCUSSION

There will be no recordings made of oral discussions. Those contributing to the discussion of a paper and desiring their remarks published will be supplied with a printed form on which any discussion may be written. These forms should be given to the Secretary-Treasurer of the Division at the end of the session. The discussion will then be referred to the authors for reply. Written discussion will be accepted up to two months following publication of any article in the JOURNAL.

A discussion section is published semiannually in the JOURNAL.

COST OF VARIOUS FUNCTIONS

(other than registration)

Wednesday Dinner, Entertainment and Cocktails	$7.00
Division Luncheons	3.00
Thursday Luncheon	3.00
Thursday Banquet (includes cocktails)	6.00
Ladies' Program	No Charge
Plant trips:	
Chrysler Engineering Laboratories,	No Charge
Ford Motor Company—Monroe, Michigan	No Charge
Dow Chemical Company—Midland, Michigan	3.00

Lunch furnished by courtesy of Dow Chemical Company

(Gratuities are included in the above costs.)

MEETING ROOM SCHEDULE

Meetings	Wednesday A.M.	Wednesday P.M.	Thursday A.M.	Thursday P.M.	Friday A.M.	Friday P.M.
Batteries			A		A	
Corrosion	B	B	B	B		
Electrodeposition				C	C	C
Electronics	C	A				
Electro-Organic	D	D	D			
Electrothermic—Industrial Electrolytic		C				
Palladium Lecture				B 4:00 P.M.		

A—Meeting will be held in Ivory Room.
B—Meeting will be held in Michigan Room.
C—Meeting will be held in Bagley Room.
D—Meeting will be held in Parlor F.

Technical Program

Wednesday, October 10, 1951

9:00 A.M.—Formal opening of the 100th Convention with Introduction by General Chairman Wright Wilson and Response by President R. M. Hunter. Michigan Room.

BATTERIES

Thursday, October 11, 1951

Primary Cell Round Table
with N. C. Cahoon presiding

(IVORY ROOM)

9:00 A.M.-12:30 P.M.—A round-table discussion of the mechanism of cathode action in alkaline primary cells, including mercuric and copper

oxides and porous gas electrodes; the magnesium anode; and anode and cathode behavior in Leclanché cells. It is hoped that an integrated discussion of these various and widely divergent electrodes may result in the formation of general concepts leading to a better understanding of each.

Panel members will be: W. C. Vosburgh, Duke University; E. A. Schumacher, National Carbon Company; and C. K. Morehouse, Olin Industries.

Friday, October 12, 1951

Storage Battery Round Table
with E. Willihnganz presiding

(IVORY ROOM)

9:00 A.M.-12:30 P.M.—A round-table discussion of reactions at the surface of lead immersed in sulfuric acid in terms of double-layer properties and rates of reaction.

Panel members will be: D. C. Grahame, Amherst College; H. Salzberg, Naval Research Laboratories; S. Schuldiner, Naval Research Laboratories; U. B. Thomas, Bell Telephone Laboratories; and C. Wagner, Massachusetts Institute of Technology.

12:30 P.M.—Battery Division Luncheon and Business Meeting. Place to be announced.

CORROSION

Wednesday, October 10, 1951

with Norman Hackerman presiding

(MICHIGAN ROOM)

9:15 A.M.—"The Nature of Zinc Corrosion Products" by P. T. Gilbert, British Non-Ferrous Metals Research Association, London, England. (Abstract No. 1)

9:45 A.M.—"The Dissolution of Magnesium in Hydrochloric Acid" by B. Roald, Norwegian Defense Research Establishment, Lillestrom, Norway, and W. Beck, American Electro Metal Corporation, Yonkers, N. Y. (Abstract No. 2)

10:05 A.M.—"The Influence of Oxygen Concentration on the Corrosion of Aluminum in Electrolytic Solutions" by W. Beck, American Electro Metal Corporation, Yonkers, N. Y., and R. G. Gold and F. Keihn, Department of Metallurgical Engineering, Lehigh University, Bethlehem, Pa. (Abstract No. 3)

10:25 A.M.—"Corrosion of Aluminum by Carbon Tetrachloride" by Milton Stern and H. H.

Uhlig, Corrosion Laboratory, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. (Abstract No. 4)

10:50 A.M.—"Effect of Oxide Films on the Reaction of Aluminum with Carbon Tetrachloride" by Milton Stern and H. H. Uhlig, Corrosion Laboratory, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. (Abstract No. 5)

11:15 A.M.—"Resistance of Titanium to Sulfuric and Hydrochloric Acids Inhibited by Ferric and Cupric Ions" by Joseph R. Cobb and H. H. Uhlig, Corrosion Laboratory, Massachusetts Institute of Technology, Cambridge, Mass. (Abstract No. 6)

11:40 A.M.—"Crystal Structure and the Corrodibility of Steels in Inhibited Hydrochloric Acid Solutions" by P. H. Cardwell, Dowell Incorporated, Tulsa, Okla. (Abstract No. 7)

12:30 P.M.—Corrosion Division Luncheon. Place to be announced.

Corrosion (cont'd.)

with Norman Hackerman presiding

(MICHIGAN ROOM)

2:00 P.M.—"Correlations Between the Parabolic Oxidation Rates of Metals and Properties of Their Oxides" by Andrew Dravnieks, Engineering Research Department, Standard Oil Company (Indiana), Chicago, Ill. (Abstract No. 8)

2:30 P.M.—"Structure and Kinetics of Formation of Anodic Coatings on Zirconium" by R. D. Misch and A. H. Roebuck, Argonne National Laboratory, Chicago, Ill. (Abstract No. 9)

3:00 P.M.—"A Spectrophotometric Study of the Oxidation of Tantalum" by J. T. Waber and G. E. Sturdy, Los Alamos Scientific Laboratory, Los Alamos, N. Mex., E. M. Wise, International Nickel Company, New York, N. Y., and C. R. Tipton, Battelle Memorial Institute, Columbus, Ohio. (Abstract No. 10)

3:30 P.M.—"Role of Crystal Orientation in the Oxidation of Iron" by Earl A. Gulbransen and Roswell Ruka, Chemical Department, Westinghouse Research Laboratories, East Pittsburgh, Pa. (Abstract No. 11)

4:00 P.M.—"Electron Diffraction Studies on the Oxidation of Pure Copper and Pure Zinc at Temperatures of 200° to 500°C" by Earl A. Gulbransen and William R. McMillan, Westinghouse Research Laboratories, East Pittsburgh, Pa. (Abstract No. 12)

4:30 P.M.—Corrosion Division Business Meeting.

Thursday, October 11, 1951

Corrosion (cont'd.)

with Norman Hackerman presiding

(MICHIGAN ROOM)

9:00 A.M.—"Passivation of Some Metals" by Rudolph Speiser, F. H. Beck, M. G. Fontana, and E. N. Lassettre, The Ohio State University, Columbus, Ohio. (Abstract No. 13)

9:30 A.M.—"Passivity of Iron Films in Nitric Acid" by Harry C. Gatos and H. H. Uhlig, Corrosion Laboratory, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. (Abstract No. 14)

10:00 A.M.—"Surface Reactions of Steel in Dilute Chromate Solutions" by Robert A. Powers and Norman Hackerman, Department of Chemistry, University of Texas, Austin, Tex. (Abstract No. 15)

10:30 A.M.—"The Rotogenerative Detection of Corrosion Currents" by J. B. McAndrew, W. H. Colner, and H. T. Francis, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill. (Abstract No. 16)

11:00 A.M. — "Thermogalvanic Potentials, II. Nickel in Neutral Nickel Sulfate Solution" by Dodd S. Carr, The International Nickel Company, Inc., Bayonne, N. J., and Charles F. Bonilla, Columbia University, New York, N. Y. (Abstract No. 17)

11:30 A.M.—"Mathematical Studies of Galvanic Corrosion, I. Coplanar Electrodes with Negligible Polarization" by J. T. Waber, Los Alamos Scientific Laboratory, Los Alamos, N. Mex. (Abstract No. 18)

12:00 M.—"Effects of Alkaline Detergents on a Magnesium Die Casting Alloy" by J. Fred Hazel, Department of Chemistry and Chemical Engineering, University of Pennsylvania, Philadelphia, Pa., and William Stericker, Philadelphia Quartz Company, Philadelphia, Pa. (Abstract No. 19)

Corrosion (cont'd.)

with Norman Hackerman presiding

(MICHIGAN ROOM)

2:00 P.M.—"The Mechanism of Dissolution of Titanium in Hydrofluoric Acid" by M. E. Straumanis and P. C. Chen, University of Missouri, School of Mines and Metallurgy, Rolla, Mo. (Abstract No. 20)

CORROSION (cont'd.)

2:30 P.M. — "Electrochemical Kinetics of the Dissolution of Metals, Especially Titanium in Acids" by M. E. Straumanis and P. C. Chen, University of Missouri, School of Mines and Metallurgy, Rolla, Mo. (Abstract No. 21)

3:00 P.M.—"A Polarographic Study of the Influence of Temperature on the Rate of Oxygen Consumption by Iron, Lead, and Zinc" by Paul Delahay, Clarence F. Pillon, Jr., and Douglas Perry, Department of Chemistry, Louisiana State University, Baton Rouge, La. (Abstract No. 22)

3:30 P.M.—"The Rate of Corrosion of Silver in Ferric Perchlorate Solutions" by Cecil V. King and Frances S. Lang, New York University, New York, N. Y. (Abstract No. 23)

4:00 P.M.—Palladium Medal Address in Michigan Room.

ELECTRODEPOSITION

Thursday, October 11, 1951

Electroplating Processes

with R. A. Woofter presiding

(BAGLEY ROOM)

1:50 P.M.—Opening Remarks.

2:00 P.M.—"The Electrodeposition of Silver on Nickel-Steel for a Glass-to-Metal Seal Arrangement" by R. T. Foley, R. D. Alvord, and J. K. Easley, General Electric Company, Pittsfield, Mass. (Abstract No. 24)

2:30 P.M.—"Plating from Alkaline Pyrophosphate Zinc Baths" by J. E. Stareck, Research Laboratories, United Chromium, Inc., Detroit, Mich. (Abstract No. 25)

3:00 P.M.—"The Electrodeposition of Aluminum from Nonaqueous Solutions" by Dwight E. Couch and Abner Brenner, National Bureau of Standards, Washington, D. C. (Abstract No. 26)

3:30 P.M.—"On Current Distribution Over a Cylinder with Hemispherical Ends" by Sidney Barnartt, Westinghouse Research Laboratories, East Pittsburgh, Pa. (Abstract No. 27)

4:00 P.M.—Palladium Medal Address in the Michigan Room.

Friday, October 12, 1951

Alloy Plating
with R. A. Woofter presiding

(BAGLEY ROOM)

9:00 A.M.—"The Mechanism of the Tungsten Alloy Plating Process" by Walter E. Clark, Department of Chemical Engineering, University of Missouri, School of Mines and Metallurgy, Rolla, Mo., and M. H. Lietzke, Oak Ridge National Laboratory, Oak Ridge, Tenn. (Abstract No. 28)

9:35 A.M. — "Tin-Zinc Plating in the United States" by Frederick A. Lowenheim, Research Laboratory, Metal & Thermit Corporation, Rahway, N. J. (Abstract No. 29)

10:10 A.M. — "Electrodeposition of Rhenium-Cobalt and Rhenium-Iron Alloys" by L. E. Netherton, Victor Chemical Company, Chicago Heights, Ill., and M. L. Holt, Chemistry Department, University of Wisconsin, Madison, Wis. (Abstract No. 30)

10:45 A.M.—"The Codeposition of Tin-Nickel from Chloride-Fluoride Electrolytes" by J. W. Cuthbertson and N. Parkinson, Tin Research Institute, Middlesex, England. (Abstract No. 31)

11:20 A.M.—"The Electrodeposition of Cobalt-Tungsten-Molybdenum Alloys from Aqueous Citrate Solutions" by R. F. McElwee, U. S. Naval Ordnance Test Station, China Lake, Calif., and M. L. Holt, Chemistry Department, University of Wisconsin, Madison, Wis. **(Abstract No. 32)**

12:30 P.M. — Electrodeposition Luncheon and Business Meeting. Place to be announced.

Control of Electrodeposits
with M. L. Holt presiding

(BAGLEY ROOM)

2:00 P.M.—"The Effect of Temperature on the Cathode Potential during Nickel Plating" by Dennis R. Turner, Electroplating Projects Laboratory, Westinghouse Electric Corporation, East Pittsburgh, Pa. (Abstract No. 33)

2:30 P.M.—"The Effect of Chloride Ions on Copper Deposition" by W. H. Gauvin, Department of Chemical Engineering, and C. A. Winkler, Department of Chemistry, McGill University, Montreal, Canada. (Abstract No. 34)

3:00 P.M.—"The Effect of Sulfates of Certain Tripositive Cations in Chromium Plating

Baths" by Earl S. Snavely and Norman Hackerman, Department of Chemistry, University of Texas, Austin, Tex. (Abstract No. 35)

3:30 P.M.—"Electrolytic Determination of Tin and Tin-Iron Alloy Coating Weights on Tin Plate" by C. T. Kunze and A. R. Willey, Research Laboratory, American Can Company, Maywood, Ill. (Abstract No. 36)

4:00 P.M.—"A Note on the Structure of Tin-Nickel Electrodeposits" by H. P. Rooksby, Research Laboratories, The General Electric Company, Limited, Wembley, England. (Abstract No. 37)

4:30 P.M.—"Stress Reduction of Electrodeposited Nickel" by Vincent J. Marchese, Sperry Gyroscope Company, Division of the Sperry Corporation, Great Neck, N. Y. (Abstract No. 38)

ELECTRONICS

Wednesday, October 10, 1951

Screen Application Methods
Panel Discussion with A. E. Hardy presiding

(BAGLEY ROOM)

10:00 A.M.-1:00 P.M.—Papers on the theoretical and practical aspects of screen application and analytical controls. All discussion of these papers will be reserved for the afternoon session.

10:00 A.M.—"Recent Investigations of Streaming Potentials at Phosphor and Glass Surfaces" by J. Fred Hazel, University of Pennsylvania, Philadelphia, Pa.

10:30 A.M.—"Gel Settling" by A. Steadman, Allen B. Dumont Labs., Inc., Allwood, N. J.

10:50 A.M. — "Liquid Settled Luminescent Screens" by S. Pakswer and Phyllis Intiso, Rauland Corporation, Chicago, Ill.

11:10 A.M.—"Quantitative Evaluation of the Bonding Properties of Liquid Settling Media for Cathode Ray Tubes" by D. J. Bracco and W. R. Watson, Sylvania Electric Products Inc., Bayside, Long Island, N. Y.

11:30 A.M.—"Screen Wet Strength Adherence as Determined by the Jet Impingement Method" by A. C. Porath and A. E. Hardy, Radio Corporation of America, Lancaster, Pa.

11:45 A.M.—Recess.

ELECTRONICS (cont'd.)

11:55 A.M.—"The Effect of Impurities in Potassium Silicate on the Region of Adherence of Phosphor Screens" by S. A. Hoshowsky and A. E. Hardy, Radio Corporation of America, Lancaster, Pa.

12:05 P.M.—"Particle Size Determination on Phosphors" by R. B. Snyder, Rauland Corporation, Chicago, Ill.

12:20 P.M.—"Water Purification for Use in Electron Tube Manufacturing" by W. J. Hindman, Lansdale Tube Company, Lansdale, Pa.

12:40 P.M.—"Volumetric Determination of Barium" by Thomas J. Manns, Margaret U. Reschovsky, Anthony J. Certa, and M. Sadowsky, Philco Corporation, Lansdale, Pa.

12:50 P.M.—"Strength Specific Gravity Curves for Potassium Silicate Solutions, with Temperature Corrections" by M. Sadowsky, Philco Corporation, Lansdale, Pa.

1:00 P.M. — Division Luncheon and Business Meeting. Place to be announced.

Screen Application Methods (cont'd.)
with A. E. Hardy presiding
(IVORY ROOM)

2:00 P.M.-5:00 P.M.—Round-Table Discussion on the morning papers and recent advances in the art of screen application.

ELECTRO-ORGANIC CHEMISTRY

Wednesday, October 10, 1951

with Hans Neumark presiding
(PARLOR F)

9:30 A.M.—"Reduction of Aromatic Nitro-Compounds to Aminophenols" by Christopher L. Wilson and Handady V. Udupa, Department of Chemistry, Ohio State University, Columbus, Ohio. (Abstract No. 39)

10:00 A.M.—"Electrolytic Reduction of Organic Compounds at Carbon Cathodes" by Sherlock Swann, Jr., C. Y. Chen, and H. D. Kerfman, University of Illinois, Urbana, Ill. (Abstract No. 40)

10:30 A.M. — "Electrolytic Oxidation of Chloracetaldehyde to Chloro Acetic Acid" by H. H. Roth, Dow Chemical Company, Midland, Mich. (Abstract No. 41)

ELECTRO-ORGANIC CHEMISTRY

11:00 A.M.—"The 'Redoxotrol' and Its Application to the Preparation of Pinacols by Controlled Cathode Potential" by Milton J. Allen, National Cancer Institute, National Institute of Health, Bethesda, Md. (Abstract No. 42)

11:30 A.M.—"Electrolytic Reduction of Aromatic Carboxylic Acids; Reduction of Benzoic-, Phenylacetic-, and Cinnamic Acid and of Their Esters at a Platinized-Platinum Cathode" by Shinichi Ono, Tadao Hayashi, and Jyunichi Nakaya, Department of Chemistry, Naniwa University, Osaka, Japan. (Abstract No. 43)

12:30 P.M.—Division Luncheon and Business Meeting. Place to be announced.

Electro-Organic Chemistry (cont'd.)
with Stanley Wawzonek presiding

(PARLOR F)

2:00 P.M. — "The Polarographic Behavior of Streptomycin" by Clark E. Bricker and W. Aubrey Vail, Department of Chemistry, Princeton University, Princeton, N. J. (Abstract No. 44)

2:30 P.M.—"The Polarography of Organic Mercury Compounds and Their Mercaptides" by Reinhold Benesch and Ruth E. Benesch, Department of Biochemistry, Northwestern University Medical School, Chicago, Ill. (Abstract No. 45)

3:00 P.M.—"A Selective Anodic Oxidation at Controlled Potential" by Alsoph H. Corwin, Hans Brauchli, and Edith C. Davis, The Johns Hopkins University, Baltimore, Md. (Abstract No. 46)

3:30 P.M.—"Some Quantum-Mechanical Aspects of Electro-Organic Chemistry" by Allan Maccoll, William Ramsay and Ralph Forster Laboratories, University College, London, W.C. 1, England. (Abstract No. 47)

4:00 P.M. — "Conductivity Measurements by Leakage Methods" by G. W. Thiessen, Monmouth College, Monmouth, Ill. (Abstract No. 48)

4:30 P.M. — "Polarography of Organic Compounds, XI. The *alpha*-Bromo-*n*-alkanoic Acids" by Isadore Rosenthal, Charles H. Albright, and Philip J. Elving, Chemistry Department, The Pennsylvania State College, State College, Pa. (Abstract No. 49)

Thursday, October 11, 1951

(PARLOR F)

9:00 A.M.-12:00 M. — Round-Table Discussion with Marshall T. Sanders, Atlas Powder Company, as moderator. Subjects and speakers are as follows:

"Reaction Mechanisms at the Dropping Mercury Electrode," Stanley Wawzonek, State University of Iowa, Iowa City, Iowa.

"Principles Underlying Electro-Organic Reactions," Christopher L. Wilson, The Ohio State University, Columbus, Ohio.

"Principles Involved in the Use of Porous Carbon Electrodes," George W. Heise, National Carbon Research Laboratories, Cleveland, Ohio.

ELECTROTHERMIC

and

INDUSTRIAL ELECTROLYTIC

Wednesday, October 10, 1951

(BAGLEY ROOM)

12:30 P.M.—Joint Electrothermic and Industrial Electrolytic Luncheon. Place to be announced.

2:00 P.M.-5:00 P.M.—Round-Table Discussion of "Power Supply and Requirements for Electrochemical Industries" with R. C. Hienton as moderator. Methods of overcoming shortages of electrical energy and various raw materials and supplies will be discussed informally by representatives of electrochemical industry, public utilities, and government.

ABSTRACTS

CORROSION

ABSTRACT NUMBER 1

THE NATURE OF ZINC CORROSION PRODUCTS

P. T. Gilbert

AN INVESTIGATION was made, using x-ray diffraction methods, of the nature of the corrosion products formed on zinc when immersed in hot or cold water, and of the changes occurring when zinc hydroxide and zinc oxide were kept hot or cold in air or under water. Complicated results were obtained, but it is clear that zinc oxide may be a product of the corrosion of zinc in water, especially at raised temperatures. The significance of the results is discussed in the light of previous work on the electrochemical behavior of zinc in hot and cold waters.

ABSTRACT NUMBER 2

THE DISSOLUTION OF MAGNESIUM IN HYDROCHLORIC ACID*

B. Roald and W. Beck

THE dissolution rate and electrode potential of magnesium have been determined as functions of acid concentration, agitation, polarization, alloy composition, and additions to the solution. The measurements offer evidence that the dissolution is diffusion controlled. The changes in the electrode potential with acid concentration depend on deposition of low overvoltage impurities on the metal surface, and the potentials are readily explained in terms of the electrochemical theory of corrosion. External polarization, by affecting the rate of transfer of hydrogen ions to the metal, decreases the dissolution rate. Notwithstanding the fact that stationary local cells are absent and the reaction is diffusion controlled, the dissolution of magnesium has to be considered electrochemical in nature.

* This work was done at Lehigh University, Bethlehem, Pa.

ABSTRACT NUMBER 3

THE INFLUENCE OF OXYGEN CONCENTRATION ON THE CORROSION OF ALUMINUM IN ELECTROLYTIC SOLUTIONS

W. Beck, R. G. Gold, and F. Keihn

THE corrosion of commercially pure aluminum in KCl solutions with various concentrations of dissolved O_2 or H_2O_2 was studied by means of weight loss and electrode potential measurements. The concentration of oxygen was increased by raising its pressure (maximum pressure 325 psi). The weight loss increased with higher concentrations of oxygen or H_2O_2 (from 0.1 to 1 per cent) and lower concentrations of KCl (from 1 to 0.0001*N*), but decreased with time. The higher corrosion rate in the very dilute solutions has been related to the presence of oxidation products of iron on aluminum, which act as cathodes. The decrease of corrosion rate with time, especially marked in dilute KCl solutions, was accomplished by increasing polarization of the local cathodes by precipitated $Al(OH)_3$ which was dissolved colloidally.

ABSTRACT NUMBER 4

CORROSION OF ALUMINUM BY CARBON TETRACHLORIDE

Milton Stern and H. H. Uhlig

WHEN aluminum (99.99%) is exposed to boiling CCl_4, reaction occurs after an induction period. This delay increases appreciably with dissolved H_2O, CS_2, or O_2 in the CCl_4, and decreases in presence of corrosion products. The corrosion rate, after the induction period, is high, approximating 40,000 mdd (20 ipy) in relatively dry CCl_4, and double this in water-saturated solvent. Oxygen, N_2, and corrosion products have no practical effect on the rate, whereas HCl increases it by 35 per cent.

The induction period for aluminum alloys is greater than for high-purity aluminum by a factor as high as 30, and the long-time corrosion rates are usually lower than for pure aluminum. This fact, combined with negligible effects of galvanic coupling or of an applied potential of 1.5

volts, suggests that direct chemical reaction occurs. It is confirmed that the main reaction is:

$$2Al + 6CCl_4 \rightarrow 2AlCl_3 + 3C_2Cl_6.$$

ABSTRACT NUMBER 5

EFFECT OF OXIDE FILMS ON THE REACTION OF ALUMINUM WITH CARBON TETRACHLORIDE

Milton Stern and H. H. Uhlig

A PREVIOUS paper showed that the protective film on aluminum delays reaction with boiling CCl_4 (induction period). Oxide films on aluminum, however, produced by anodizing did not effectively improve the ultimate resistance to attack, whether the anodizing was done in the laboratory or commercially. Heating aluminum at 235°C improved resistance, but not to a practical extent. The natural oxide film on evaporated aluminum films is very protective, but this quality is easily lost by scratching and otherwise damaging the surface. Alloying elements in aluminum are far more effective in building up resistance to attack by carbon tetrachloride.

ABSTRACT NUMBER 6

RESISTANCE OF TITANIUM TO SULFURIC AND HYDROCHLORIC ACIDS INHIBITED BY FERRIC AND CUPRIC IONS

Joseph R. Cobb and H. H. Uhlig

THE corrosion of titanium in boiling 10 per cent sulfuric and boiling 10 per cent hydrochloric acids was inhibited by Fe^{+++} or Cu^{++} ions. The corrosion rates range from 3 to 55 mdd (0.001 to 0.012 ipy) for inhibitor concentrations from 0.03 to 0.005 mole/l. Although the inhibitors are consumed as titanium corrodes, the consumption is moderate, particularly at the higher inhibitor concentrations for which corrosion rates are lower. The primary mechanism, as indicated by potential measurements, is proposed as occurring through adsorption of Fe^{+++} and Cu^{++} on the metal surface with accompanying satisfaction of surface valences and formation of a dipole layer with negative charge outward accounting for a noble potential.

ABSTRACT NUMBER 7

CRYSTAL STRUCTURE AND THE CORRODIBILITY OF STEELS IN INHIBITED HYDROCHLORIC ACID SOLUTIONS

P. H. Cardwell

IN A STUDY of the corrodibility of steels it was found that the degree of annealing, as measured by the resolution of the pearlite, the grain size, and the presence of the Widmanstatten structure, has considerable influence on the corrosion rate of the steels. Two acid inhibitors were examined in order to investigate materials which could satisfactorily be used to protect different crystal structure steels during industrial applications of inhibited hydrochloric acid solutions.

ABSTRACT NUMBER 8

CORRELATIONS BETWEEN THE PARABOLIC OXIDATION RATES OF METALS AND PROPERTIES OF THEIR OXIDES

Andrew Dravnieks

FROM the literature data on oxidation of metals certain crude generalizations can be drawn, relating parabolic oxidation rates to some physical properties of the oxides formed. The rate constants, compared at definite fractions of the melting temperature and corrected for molevolumes and free energy changes, fall into definite groups, which depend on metal ion valency, oxide lattice type, and oxygen solubility in the metal. For divalent oxides, the activation energies vary systematically with electron density.

ABSTRACT NUMBER 9

STRUCTURE AND KINETICS OF FORMATION OF ANODIC COATINGS ON ZIRCONIUM

R. D. Misch and A. H. Roebuck

THICK oxide coatings can be produced on zirconium by anodizing under more corrosive conditions than generally used for aluminum. Zirconium is intermediate between alumnium and titanium in the stability and growth of the barrier layer.

Oxalic acid and mixtures of sulfuric and nitric acids were studied in detail and other electrolytes surveyed. Crystalline films are formed at high voltages while an amorphous film forms at low voltages in nitric acid. The mechanism of film formation under various conditions is indicated by voltage and current vs. time curves. Results are dependent on metal purity and alloy content.

ABSTRACT NUMBER **10**

A SPECTROPHOTOMETRIC STUDY OF THE OXIDATION OF TANTALUM

J. T. Waber, G. E. Sturdy, E. M. Wise, and C. R. Tipton

THE air oxidation of tantalum, over the temperature range 220°-350°C, has been studied by the newly-developed spectrophotometric technique and by conventional microgravimetric methods. Good agreement is noted for the data obtained by the two methods.

Another method of potential interest, still unexploited, is revealed. This technique involves measurements of the reflectance of a surface as oxidation proceeds.

ABSTRACT NUMBER **11**

ROLE OF CRYSTAL ORIENTATION IN THE OXIDATION OF IRON

Earl A. Gulbransen and Roswell Ruka

THE interface between a metal and its oxide or other corrosion films is a zone of great interest in the general phenomena of protection of metals. The system of iron and its oxides is considered in this work. Experiments are made using the electron diffraction high temperature camera on the oxidation of single crystals of iron. Definite orientation effects are found between the metal and the oxide if the oxidation is carried out slowly, for example, in a 50% H_2O-50% H_2 mixture at 750°C or in high vacuum. Rapid oxidation

shows that the original orientation effects are not carried through to thick films.

The orientation effects are interpreted in terms of two principles: (1) the conservation of similar repeat distances in the two lattices and (2) conservation of atom density. The effect of the forward and reverse solid phase reaction $Fe_3O_4 + Fe \rightarrow 4FeO$ is studied and it is shown that the orientation effects are carried through to the newly-formed oxide. The results are discussed in their relationships to the general phenomena of oxidation and corrosion.

ABSTRACT NUMBER 12

ELECTRON DIFFRACTION STUDIES ON THE OXIDATION OF PURE COPPER AND PURE ZINC AT TEMPERATURES OF 200° TO 500°C

Earl A. Gulbransen and William R. McMillan

PREVIOUS workers have identified an oxide CuO[1] which is found in addition to Cu_2O and CuO during the oxidation of copper. Studies on commercial copper, pure copper, electrodeposited copper, and evaporated copper show that the diffraction ring characteristic of CuO[1] may also be interpreted as due to an oxide of lead. This impurity, although present in trace amounts, concentrates in the surface layer during oxidation. Cu_2O is formed by the solid phase reaction of copper with CuO. These observations show that at temperatures of 200° to 500°C copper ions diffuse through the Cu_2O structure.

Finch and Quarrell[1] in a study of the oxides formed on molten zinc postulate an oxide pseudomorphic with zinc in addition to normal ZnO. Oxidation studies using super-pure zinc rods and evaporated zinc specimens at temperatures of 100° to 375°C give electron diffraction patterns of zinc and normal ZnO. No evidence is found for the pseudomorphic oxide.

[1] FINCH AND QUARRELL, *Proc. Phys. Soc. (London)*, **46**, 148 (1934).

ABSTRACT NUMBER 13

PASSIVATION OF SOME METALS*

Rudolph Speiser, F. H. Beck, M. G. Fontana, and E. N. Lassettre

THE passivation of stainless steel by O_2 is reversible. A film of oxygen chemically bonded to form the oxide does not form a protective film against the action of a corrosive solution of H_2SO_4 whereas a film of O_2 is passivating. It is suggested that O_2 in a $^3\Sigma$ state behaves as a free radical and is more strongly adsorbed by the residual valences of the metal surface than gases such as He and H_2 which are only physically adsorbed. However, the bond order between the oxygen and the metal is only a fraction of a single bond. Therefore, although O_2 can be desorbed in a vacuum it can still form a metastable film which can passivate against some corrosive media.

* This work was carried out under contract between ONR and The Ohio State University Research Foundation.

ABSTRACT NUMBER **14**

PASSIVITY OF IRON FILMS IN NITRIC ACID

Harry C. Gatos and H. H. Uhlig

THE passivity of iron in nitric acid (sp gr 1.42) was studied by employing iron films evaporated on glass in vacuum. Pre-exposure to O_2 causes iron to become passive after 0.08 mg Fe/cm^2 reacts, which is approximately one-half that reacting if films are not pre-exposed. The effect of O_2 exposure could be eliminated by evacuation. Pre-exposure to CO also reduces the iron reacting before passivity. $N_2$and H_2O were without effect, whereas pre-exposure to 0.1 per cent $K_2Cr_2O_7$ solution prevented any attack by HNO_3. The effect of chromate could be washed off only partially. A mechanism for the observed phenomena is proposed.

ABSTRACT NUMBER **15**

SURFACE REACTIONS OF STEEL IN DILUTE CHROMATE SOLUTIONS

Robert A. Powers and Norman Hackerman

RADIOACTIVE sodium chromate solutions were used to investigate the passivating and inhibitory action of chromate on steel. A definite amount of chromate was required to give passive

surface. This increased with decreasing *p*H in a manner explainable by changes in ionic composition of the solutions. Contact potentials were related to chromate retained on the surface. Radioautographs were used to show the chromate distribution. In solutions too dilute to passivate, chromate uptake increased several fold. The results are best explained by adsorption of chromate and other anions by the steel.

ABSTRACT NUMBER 16

THE ROTOGENERATIVE DETECTION OF CORROSION CURRENTS

J. B. McAndrew, W. H. Colner, and H. T. Francis

A NEW technique is described which permits detection of local cell corrosion currents. A cylindrical specimen, rotating in the corrosion medium, is scanned by a reference electrode. This (AC) signal, combined with a synchronized sweep voltage, is viewed on an oscilloscope. The standing pattern produced reproduces the potential fields generated in the medium by currents flowing between local cell elements.

ABSTRACT NUMBER 17

THERMOGALVANIC POTENTIALS
II. Nickel in Neutral Nickel Sulfate Solution*

Dodd S. Carr and Charles F. Bonilla

THERMOGALVANIC corrosion is a form of galvanic action in which metal dissolves from one surface and is deposited on another as the result of a temperature difference between the two surfaces. An apparatus was constructed for measuring reproducible thermogalvanic potentials developed by carefully purified nickel powder in several concentrations of neutral nickel sulfate solution under temperature differentials up to 100°C. The thermogalvanic potential of nickel was found to vary linearly with temperature difference and exponentially with the nickel concentration in the electrolyte. In 1.0 molar

* This work was done at The Johns Hopkins University, Baltimore, Md.

nickel sulfate a potential difference of 87 millivolts was developed by a temperature gradient of 100°C. The value of the standard electrode potential of nickel determined with the above apparatus was -0.236 ± 0.002 volt on the hydrogen scale, in close agreement with the average of the most widely accepted of the previously reported values.

ABSTRACT NUMBER **18**

MATHEMATICAL STUDIES OF GALVANIC CORROSION

I. Coplanar Electrodes with Negligible Polarization*

J. T. Waber

A MATHEMATICAL model for galvanic corrosion has been proposed and studied. Coplanar arrangement is used and has the advantage that it may be applied to the corrosion of two-phase alloys as well as to planar arrangements of dissimilar metals. Distribution of potential, distribution of corrosion attack near the electrode junction, and average corrosion rate are derived for certain values of the ratio of anode to the sum of the anode and cathode areas. Qualitative and some quantitative comparisons between experimental data and theoretical results are made.

* Based upon a portion of manuscript prepared at Illinois Institute of Technology, Chicago, Ill.

ABSTRACT NUMBER **19**

EFFECTS OF ALKALINE DETERGENTS ON A MAGNESIUM DIE CASTING ALLOY

J. Fred Hazel and William Stericker

TEST panels of a magnesium die casting alloy, ASTM designation AZ91, have been immersed in still and electrolytic baths of alkaline electrolytes at 90°C. Weight changes and the appearance of the treated panels were noted. The metal was not attacked by sodium hydroxide, sodium orthophosphate, and the more alkaline silicates, except when it was the anode. The magnesium

ion sequesterers, tetrasodium pyrophosphate, Calgon, and Quadrafos caused marked weight losses. Attack of the metal occurred in all cases where it was used as the anode.

ABSTRACT NUMBER 20

THE MECHANISM OF DISSOLUTION OF TITANIUM IN HYDROFLUORIC ACID

M. E. Straumanis and P. C. Chen

IT WAS proved by titration and by gasometric analysis that the reaction of dissolution of Ti in HF is: $2Ti + 6HF = 2TiF_3 + 3H_2$ or $Ti + 3H^+ = Ti^{3+}$. This reaction is electrochemical in nature because the rate of reaction is greatly influenced by presence of foreign ions in the acid, tne dissolving titanium exhibits the difference effect, and there is a connection between the potential of the dissolving metal, the surface layer on it, and the rate of dissolution.

ABSTRACT NUMBER 21

ELECTROCHEMICAL KINETICS OF THE DISSOLUTION OF METALS, ESPECIALLY TITANIUM IN ACIDS

M. E. Straumanis and P. C. Chen

DETAILED studies of the dissolution rates of Zn and Al in acids showed that the rates observed cannot be explained by the law of mass action. A qualitative explanation of the rates, including the difference effect, can be achieved on the basis of the electrochemical concept incorporated in the formula $\Delta v/\Delta t = kFz'(\epsilon' - \eta)/r$, where $\Delta v/\Delta t$ is the rate of dissolution, k is a constant, F the surface area, z' the number of active cathodes per surface unit, ϵ' the dissolution potential of the basic metal, η the overvoltage of the local cathode, and r the average resistance of a local cell. The applicability of the formula for the explanation of the rates of dissolution of Ti in acids will be given.

ABSTRACT NUMBER **22**

A POLAROGRAPHIC STUDY OF THE INFLUENCE OF TEMPERATURE ON THE RATE OF OXYGEN CONSUMPTION BY IRON, LEAD, AND ZINC

Paul Delahay, Clarence F. Pillon, Jr., and Douglas Perry

RATES of oxygen consumption by iron, lead, and zinc in an acetate buffer of *p*H 5.0 are determined at various temperatures. The specimen is placed in a closed vessel containing the buffer solution initially saturated with air at the temperature of the experiment, and the oxygen concentration is measured by the polarographic method at regular intervals. Experimental data are analyzed by assuming that the over-all rate of oxygen reduction is controlled by rate of the chemical reaction and by diffusion of oxygen toward the metal surface. It was found that the diffusion phenomenon is the predominant factor controlling the over-all rate. The influence of the rate of the chemical process is by no means negligible as shown by the difference in behavior of the various metals studied in the present investigation.

ABSTRACT NUMBER **23**

THE RATE OF CORROSION OF SILVER IN FERRIC PERCHLORATE SOLUTIONS

Cecil V. King and Frances S. Lang

A PREVIOUS paper reported that silver dissolves much more slowly in ferric perchlorate and nitrate solutions than in ferric sulfate[1]. The rate in ferric perchlorate is now presented in detail, with the effect of concentration of ferric, ferrous, and silver ions, of inert salts, agitation, temperature, electrical polarization, etc. Anion effect on the adsorption of silver salts on silver is responsible for the difference in rates.

[1] SALZBERG AND KING, *J. Electrochem. Soc.*, **97**, 290 (1950).

ELECTRODEPOSITION

ABSTRACT NUMBER 24

THE ELECTRODEPOSITION OF SILVER ON NICKEL-STEEL FOR A GLASS-TO-METAL SEAL ARRANGEMENT

R. T. Foley, R. D. Alvord, and J. K. Easley

A METHOD of silver plating a 42% nickel-58% iron alloy to produce an electrodeposit capable of withstanding an anneal at 850°C is given. The surface preparation of the steel, the proper salt concentration of the "strike" bath, and the plating step are described. No nickel or copper undercoating is used to achieve an adherent coating. The diffusion of oxygen through this silver plate is hindered by a thin coating of indium which also operates in the glass-to-metal seal.

ABSTRACT NUMBER 25

PLATING FROM ALKALINE PYROPHOSPHATE ZINC BATHS

J. E. Stareck

A NEW process is described whereby zinc is plated on iron and steel, or other basic metals, from an alkaline pyrophosphate zinc solution. The process is characterized by better throwing power, low hydrogen embrittlement, and minimum waste disposal problems. Other interesting properties and operating details are described.

ABSTRACT NUMBER 26

THE ELECTRODEPOSITION OF ALUMINUM FROM NONAQUEOUS SOLUTIONS

Dwight E. Couch and Abner Brenner

AN INVESTIGATION of the effect of various inorganic addition agents on the type of deposit produced from the fused aluminum bromide-potassium bromide bath has been made.

A new bath for the electrodeposition of aluminum has been developed. It consists of an ethereal solution of aluminum chloride to which lithium, or lithium-aluminum, hydride has been added. The deposits are quite ductile and deposition rates of 0.001 to 0.002 in. per hour are possible. Deposits of 0.02 to 0.035 in. thick have been produced, with Vickers hardnesses ranging from 37 to 97. The baths are easy to prepare, give off no corrosive fumes, and are not highly sensitive to moisture, although bath life is much longer if the solutions are protected from the air.

ABSTRACT NUMBER **27**

ON CURRENT DISTRIBUTION OVER A CYLINDER WITH HEMISPHERICAL ENDS

Sidney Barnartt

THE purpose of this study was to design an electrode that would yield relatively uniform primary current distribution over a cylinder with hemispherical ends. The designing was carried out using the electrolytic trough method of mapping equipotential surfaces between electrodes. Current distributions derived from the equipotential maps were compared with the distributions of electrodeposited chromium. Deviations between the two distributions, which are a measure of the effect of anode polarization during chromium plating, were generally small.

ABSTRACT NUMBER **28**

THE MECHANISM OF THE TUNGSTEN ALLOY PLATING PROCESS*

Walter E. Clark and M. H. Lietzke

THE mechanism of tungsten alloy plating is investigated. Absorption spectra indicate the possibility of cobalt tungstate complexes in the citrate plating bath. Polarographic evidence is given for the existence of complexes of tungstate and citrate. Calculation of energies of activation show that the tungstate reaches the cathode by diffusion rather than by migration. The mecha-

* This work was done at the Department of Chemistry, University of Wisconsin, Madison, Wis.

nism postulated for the plating of tungsten alloys includes (*a*) the deposition of a film of partly reduced tungstate on the cathode and (*b*) the catalytic reduction of this film by hydrogen in the presence of freshly deposited iron, cobalt, or nickel.

ABSTRACT NUMBER 29

TIN-ZINC PLATING IN THE UNITED STATES

Frederick A. Lowenheim

THE process for plating the 80-20 tin-zinc alloy was originally developed by the Tin Research Institute in England and has been fully described in a communication to The Electrochemical Society by Cuthbertson. The present paper will describe later work on this process, including the development of an all-potassium bath and the changes required to adapt the process to barrel plating. American experience with the process will also be outlined and test results on corrosion resistance will be given.

ABSTRACT NUMBER 30

ELECTRODEPOSITION OF RHENIUM-COBALT AND RHENIUM-IRON ALLOYS

L. E. Netherton* and M. L. Holt

THE electrodeposition of rhenium-cobalt and rhenium-iron alloys from an aqueous ammoniacal citrate solution is described. Effects of bath composition, *p*H, temperature, and current density on cathode current efficiency and composition of the alloy deposit were studied. A rhenium-cobalt solution containing 60 g/l of $CoSo_4 \cdot 7H_2O$, 10 g/l of $KReO_4$, 66 g/l of citric acid, and NH_4OH to *p*H 7, when electrolyzed at 5 amp/dm^2 and 70°C gave a cathode deposit containing 75 per cent rhenium with a current efficiency of about 85 per cent. A similar rhenium-iron solution containing 59.4 g/l of $FeSO_4 \cdot 7H_2O$, 10 g/l of $KReO_4$, 66 g/l of citric acid, and NH_4OH to *p*H 7, when electrolyzed at the same conditions gave a cathode deposit containing 85 per cent rhenium with a current efficiency of 65 per cent.

* Present address: Victor Chemical Company, Chicago Heights, Illinois.

ABSTRACT NUMBER 31

THE CODEPOSITION OF TIN-NICKEL FROM CHLORIDE-FLUORIDE ELECTROLYTES

J. W. Cuthbertson and N. Parkinson

THE effect of variables on the composition and properties of the plate in the codeposition of tin and nickel from an electrolyte containing stannous chloride, nickel chloride, sodium fluoride, and ammonium bifluoride has been examined. The conductivity of the electrolyte has been determined and the throwing power evaluated and measured quantitatively. The relationship between electrolyte constitution and stress in the cathode deposit has been ascertained. Some insight into the mechanism of the deposition process has been obtained by measuring deposition potentials and a tentative theory of the deposition process, based on the presence in the electrolyte of a tin-nickel-fluorine complex ion, is advanced.

ABSTRACT NUMBER 32

THE ELECTRODEPOSITION OF COBALT-TUNGSTEN-MOLYBDENUM ALLOYS FROM AQUEOUS CITRATE SOLUTIONS

R. F. McElwee* and M. L. Holt

THE electrodeposition of cobalt-tungsten-molybdenum alloys is described. The aqueous plating bath is prepared from sodium tungstate, sodium molybdate, cobalt sulfate, and citric acid. The *p*H of the solution is adjusted by the addition of either ammonium hydroxide or dilute sulfuric acid. The Hull cell and regular plating procedures were used to determine optimum bath concentrations and electrolysis conditions. It was found that a bath containing 0.23 mole/l of cobalt sulfate, a total of 0.23 mole/l of sodium tungstate and sodium molybdate (W: Mo mole ratio of 7:3), and 0.31 mole/l of citric acid gave satisfactory performance. When this plating solu-

* Present address: U. S. Naval Ordnance Test Station China Lake, Calif.

tion was adjusted to *p*H 4 and maintained at 25°C, electrolysis at 5 amp/dm² gave a cathode deposit containing 66 per cent cobalt, 21 per cent molybdenum, and 13 per cent tungsten with a cathode current efficiency of 73 per cent.

ABSTRACT NUMBER 33

THE EFFECT OF TEMPERATURE ON THE CATHODE POTENTIAL DURING NICKEL PLATING

Dennis R. Turner

THE effect of temperature on the cathode potential during nickel plating was studied at current densities ranging from 0.4 to 100 ma/cm² and at temperatures from 20° to 90°C. The cathode potential-temperature relation is linear at potentials more negative than about −0.42 volt. The E_c-T straight lines extrapolated converge at about 0 volts and 165°C. An empirical equation was developed from the data: $E_c = 0.0034(4i^{1/4} + 1)(T\text{-}T^\circ)$. The results are explained on the basis of nickel ion diffusion being the rate determining step.

ABSTRACT NUMBER 34

THE EFFECT OF CHLORIDE IONS ON COPPER DEPOSITION*

W. H. Gauvin and C. A. Winkler

ADDITION of chloride ions to an acidified copper sulfate solution had no effect on the electrode processes below a definite minimum concentration, corresponding to the precipitation of cuprous chloride. The latter was adsorbed by the deposit and acted as a mild addition agent, decreasing the grain size with a corresponding increase in hardness and reflectivity of the deposit, and a small increase in polarization. Increased powder formation and, at high chloride concentration, formation of cuprous chloride, were noted at the anode. The general behavior was not affected by the addition of bindarine to the

* Contribution from the Physical Chemistry Laboratory, McGill University, with financial assistance from the National Research Council, Canada.

electrolyte, but gelatin considerably increased the powder formation, the latter being maximal at given chloride and gelatin concentrations, and prevented the chloride from entering the deposit, presumably owing to the formation of a gelatin-cuprous chloride complex.

ABSTRACT NUMBER 35

THE EFFECT OF SULFATES OF CERTAIN TRIPOSITIVE CATIONS IN CHROMIUM PLATING BATHS

Earl S. Snavely and Norman Hackerman

THE characteristics of electrodeposited chromium using a 100:1 plating solution to which gallium or aluminum sulfate had been added were studied. Certain concentrations of these sulfates were found to be advantageous in securing bright deposits over a wide range of current densities. The characteristic crack network was reduced, giving the plate better protective ability, but was never entirely absent. Electron diffraction studies indicated an amorphous deposit while x-ray diffraction gave evidence of preferred orientation. The sulfates were neither beneficial nor deleterious with respect to hardness, flexibility, or current efficiency.

ABSTRACT NUMBER 36

ELECTROLYTIC DETERMINATION OF TIN AND TIN-IRON ALLOY COATING WEIGHTS ON TIN PLATE

C. T. Kunze and A. R. Willey

IN APPROXIMATELY 1*N* halogen acid solutions, tin will deplate with full current efficiency. In contrast with anodic stripping in alkaline electrolytes, the action does not stop at the tin-iron alloy surface, but the alloy layer deplates as well. With a reference electrode, the time-potential curve will give both endpoints and make possible an accurate estimation of coating weights. The apparatus with a specially built d-c power source is described.

ABSTRACT NUMBER **37**

A NOTE ON THE STRUCTURE OF TIN-NICKEL ELECTRODEPOSITS

H. P. Rooksby

THE crystal structure of tin-nickel electrodeposits of a range of compositions has been investigated by x-ray methods. Electrodeposits of compositions extending from 56 per cent to nearly 80 per cent by weight of tin are shown to consist of a metastable single-phase alloy. The crystal structure is similar to that of the gamma Ni_3Sn_2 phase, but the hexagonal structure cell dimensions, with $a_0 = 4.15$Å, $c_0 = 5.10$Å, $c/a = 1.23$, differ appreciably from established values for Ni_3Sn_2. Variations from these dimensions with composition of the electrodeposit are small. The structure is maintained on heating to 300°C, but above this temperature the alloy begins to decompose, and mixtures of the more usual equilibrium phases, Ni_3Sn_2 and Ni_3Sn_4, are disclosed on x-ray examination.

Bright electrodeposits exhibit both strong directionally orientated effects and small crystallite size, but in specially prepared dull specimens directional orientation is either absent or much less pronounced.

ABSTRACT NUMBER **38**

STRESSS REDUCTION OF ELECTRODEPOSITED NICKEL

Vincent J. Marchese

THIS paper describes tests conducted to investigate the possibilities of electroforming low-stress nickel microwave plumbing. Two methods were studied: the use of saccharin as an addition agent in a standard Watts bath, and the superimposition of alternating current on direct current. Saccharin reduces stress in nickel deposited from the Watts bath; it is unstable, however, provides erratic results, and is difficult to control. Superimposing alternating current on direct current reduces stress considerably in nickel deposited from the Watts bath. Results verify and extend findings of previous investigations showing that stresses as low as 2000 psi can be obtained by superimposing 60-cycle alternating current on direct current in a Watts bath.

ABSTRACT NUMBER **39**

REDUCTION OF AROMATIC NITRO-COMPOUNDS TO AMINOPHENOLS

Christopher L. Wilson and Handady V. Udupa

THE influence of various factors on the yield of aminophenol from 6-chloro-2-nitrotoluene has been investigated. The most important increase resulted from efficient agitation. This was experimentally attained by high speed rotation of a cylindrical or disk cathode (copper or monel). Current efficiency, already high, increased to about 100 per cent. Above a certain speed (1000 rpm) of rotation, further increase had little effect on yield of *p*-aminophenol. This shows that the slow step is diffusion. Enhanced diffusion gets the intermediate hydroxylamine away from the cathode before it can reduce further.

Amalgamation of the cathode raised aminophenol from 21 to 58 per cent with a stationary and 37 to 71 with a rotating copper electrode. This is thought to be caused by a reduction of the catalytic effect of the cathode. Increase in temperature and acid strength also raised aminophenol; in each case, it is thought, by increasing the speed of the rearrangement reaction rather than further reduction. Increase in the ratio of nitrocompound to catholyte reduced aminophenol but left amine constant due to tarry products. These probably result by reaction of the intermediate hydroxylamine with nitro-compound.

Current density was increased from 0.4 to 4 amp/dm^2 using a rotating cathode without seriously affecting yield. This contrasts strongly with the behavior of a stationary electrode when the yield drops to almost half.

Using preferred conditions (20% acid, rotating amalgamated monel, 90°, current density 4 amp/dm^2), the following nitro-compounds were reduced to give aminophenols in the yields indicated.

2-nitro-6-chlorotoluene	(70)
2-nitro-4-chlorotoluene	(82)
o-nitrotoluene	(74)
o-nitrochlorobenzene	(76)
2,5-dichloronitrobenzene	(72)
nitrobenzene	(72)

ABSTRACT NUMBER **40**

ELECTROLYTIC REDUCTION OF ORGANIC COMPOUNDS AT CARBON CATHODES

Sherlock Swann, Jr., C. Y. Chen, and H. D. Kerfman

A STUDY has been carried out of the reduction at cathodes of graphite, gas-baked coke, and lampblack of the following compounds: maleic acid, pyridine, acetophenone oxime, benzophenone oxime, diethyl ketoxime, benzonediazonium chloride, azobenzene, dibutyl disulfide, oxalic acid, methylene blue, potassium benzenediazotate, *N*-benzohydrylidene-aniline, phenylthioacetamide, and potassium glyoxylate.

ABSTRACT NUMBER **41**

ELECTROLYTIC OXIDATION OF CHLORACETALDEHYDE TO CHLORO ACETIC ACID

H. H. Roth

CHLORACETALDEHYDE was electrolytically oxidized to chloro acetic acid over a lead anode in 30 per cent sulfuric acid. Current efficiencies of 81 per cent were obtained with a yield of 89 per cent at conversions of 21 per cent to chloro acetic acid. A current density of 0.002 amp/cm² was required. The corrosion rate of the lead anode was uneconomically high —1.12 x 10° mld.

ABSTRACT NUMBER **42**

THE "REDOXOTROL" AND ITS APPLICATION TO THE PREPARATION OF PINACOLS BY CONTROLLED CATHODE POTENTIAL

Milton J. Allen

THE apparatus which was previously described has been modified so as to overcome the potential difference between the reference potential imposed on the cell and that potential measured by a vacuum tube voltmeter placed across the standard calomel electrode and the cathode. This has been achieved by redesigning the amplifier so as to give increased amplification and using double wires to both the anode and cathode.

The preparation of a number of pinacols will be described and the effects of reference potential change and variation in background media on products formed will be discussed.

ABSTRACT NUMBER **43**

ELECTROLYTIC REDUCTION OF AROMATIC CARBOXYLIC ACIDS

Reduction of Benzoic-, Phenylacetic- and Cinnamic Acid and of Their Esters at a Platinized-Platinum Cathode

Shinichi Ono, Tadao Hayashi, and Jyunichi Nakaya

THE mechanism of reduction at a platinized-platinum cathode was quite different from that pursued at lead or mercury. The catalytic reaction was studied in the electrolytic reduction of aromatic carboxylic acids and of their esters using platinized-platinum cathode in alcoholic sulfuric acid. The reduction of benzoic-, phenylacetic- and cinnamic acid and of their alkyl esters gave rise to cyclohexyl compounds, respectively. The phenyl and benzyl esters gave the corresponding cyclohexyl esters. In the case of cinnamic acid, the ethylenic double bond was more easily reduced than the nuclear double bond. No bimolecular compounds were produced. It was shown that the reduction of the carbonyl group in these compounds was resistant to catalytic action. The optimum current density, temperature, and hydrogen pressure have been determined for the hydrogenation process.

ABSTRACT NUMBER **44**

THE POLAROGRAPHIC BEHAVIOR OF STREPTOMYCIN

Clark E. Bricker and W. Aubrey Vail

THE reduction of streptomycin and mannosidostreptomycin at the dropping mercury electrode has been studied over a wide *p*H range. Below a *p*H of 4, these compounds are not reducible, whereas between a *p*H of about 4.5 and 12.5 the polarograms show two waves. At *p*H's of 13 or higher, a single polarographic wave is obtained.

The I_D values for the polarographic waves have been plotted as a function of *p*H and compared with the titration curve obtained when a streptomycin salt is titrated with sodium hydroxide solution. The ultraviolet transmission curves of streptomycin as a function of *p*H are also compared with the polarographic data.

The polarographic behavior of the streptomycins has been interpreted from its spacial configuration, its acid-base behavior, and from the known behavior of the "free" aldehyde group in these compounds. To substantiate this interpretation, the temperature coefficient of the I_D values at various *p*H's and the fact that the two polarographic waves merge at elevated temperatures will be discussed. Furthermore, the significance of this explanation of the polarographic behavior will be mentioned with regard to the kinetics of the alkaline decomposition of the streptomycins.

ABSTRACT NUMBER **45**

THE POLAROGRAPHY OF ORGANIC MERCURY COMPOUNDS AND THEIR MERCAPTIDES

Reinhold Benesch and Ruth E. Benesch

WE HAVE shown that phenylmercuric compounds and mercurated allylanides are reduced at the dropping mercury electrode with the uptake of two electrons and the intermediate formation of organomercury free radicals. In this way a specific and direct assay of organically bound mercury becomes possible. The method has been extended to a study of the reaction be-

tween organic mercury compounds and mono- and dithiols, since the resulting mercaptides are also electroreducible. Some of the reaction mechanisms will be discussed.

ABSTRACT NUMBER **46**

A SELECTIVE ANODIC OXIDATION AT CONTROLLED POTENTIAL

Alsoph H. Corwin*, Hans Brauchli, and Edith C. Davis*

THE oxidation of diphenylthiocarbazide (I) to the corresponding carbazone (II) (dithizone) is difficult to stop and may yield the undesired compound (III):

$$C_6H_5NHNHCNHNHC_6H_5 \rightarrow C_6H_5N{=}NCNHNHC_6H_5$$
$$\quad\quad\quad

resonance energy difference is between the ion and the molecule, e.g.,

$$R + e \rightleftarrows R^-$$

$$\text{or} \quad R + 2e \rightleftarrows R^=.$$

In the third series it is the difference in resonance energy between the free radical and the aldehyde, e.g.,

$$CH_3(CH{=}CH)_n - CHO + e + H^+ \rightleftarrows$$

$$CH_3(CH{=}CH)_n - \dot{C}HOH.$$

In each series, the greater the resonance stabilization of the compound on the right hand side of the above equation over that on the left, the more positive the potential, that is the greater the ease of reduction. The assumptions made in the treatment are discussed, together with the possibility of relaxing some of them.

ABSTRACT NUMBER 48

CONDUCTIVITY MEASUREMENTS BY LEAKAGE METHODS

G. W. Thiessen

THE conductivity of pure aniline has been shown to be lower than any values previously recorded. This work, done by means of substitution methods using ballistic galvanometer and condenser system, has shown that the conductivity of pure aniline is increased by acetanilide and aniline oxidation products.

ABSTRACT NUMBER 49

POLAROGRAPHY OF ORGANIC COMPOUNDS

XI. The *alpha*-Bromo-*n*-alkanoic Acids

Isadore Rosenthal, Charles H. Albright, and Philip J. Elving

A POLAROGRAPHIC study of the saturated straight-chain *alpha*-bromoalkanoic acids, from acetic to caprylic inclusive, indicates an initially similar pattern of behavior for all involving the fission of the carbon-halogen bond and the conversion of the corresponding acid. As the

chain length increases, the ease to reduction increases at all *p*H values, with the one exception that the bromopropionic acid in the alkaline region is more difficultly reducible than the bromobutyric acid.

Maxima effects found with the acids can apparently be ascribed to the colloidal behavior of the acids upon dilution with buffers in which the reducible acid has lower solubility than impure water.

The effects of ethanol on half-wave potential and diffusion current have been investigated with representative members of the series. In the alkaline region $E_{1/2}$ increases and i_d decreases as the alcohol content increases. The evidence in the acid region, though not entirely conclusive, indicates the reverse effect with regard to half-wave potential.

SPRING MEETING
GOLDEN JUBILEE

at the

BENJAMIN FRANKLIN HOTEL
Philadelphia, Pennsylvania

May 4 to 8, 1952

SESSIONS ON

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Abstracts for the Spring Meeting (not exceeding 75 words in length) are due at the Secretary's Office, 235 West 102nd Street, New York 25, New York, not later than February 1, 1952.

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